Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

MARINE INVESTIGATION REPORT M17P0052

Capsizing and sinking with loss of life

Fishing vessel *Miss Cory*
Strait of Georgia, British Columbia
06 March 2017

Canada

Transportation Safety Board of Canada
Place du Centre
200 Promenade du Portage, 4th floor
Gatineau QC K1A 1K8
819-994-3741
1-800-387-3557
www.tsb.gc.ca
communications@tsb.gc.ca

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Marine investigation report M17P0052

Cat. No. TU3-7/17-0052E-PDF
ISBN 978-0-660-26853-8

This report is available on the website of the Transportation Safety Board of Canada at www.tsb.gc.ca

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The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

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Capsizing and sinking with loss of life
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Summary

On 06 March 2017 at approximately 1545 Pacific Standard Time, the fishing vessel *Miss Cory*, while seining for herring with 5 people on board, took on water, capsized, and sank in the Strait of Georgia, British Columbia. As the *Miss Cory* capsized, 4 people transferred to the fishing vessel *Proud Venture*, whose crew was helping to harvest the fish. One person who was in the engine room at the time of the capsizing was subsequently reported missing. Minor pollution was reported.

Le présent rapport est également disponible en français.

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1.0 *Factual information*

1.1 *Particulars of the vessel*

Table 1. Particulars of the vessel

Name of vessel	*Miss Cory*
Official/licence number	188627/VRN 21801
Port of registry	Prince Rupert, BC
Flag	Canada
Type	Fishing, seiner
Gross tonnage	87.09
Length	19.51 m
Built	1956, Matsumoto & Sons Shipyard, Dollarton, BC
Propulsion	2 diesel engines (294 BHP) driving a single propeller
Cargo	Approximately 40 tons of herring in forward holds
Crew	5
Registered owner	Private owner (Prince Rupert, BC)

1.2 *Vessel description*

The *Miss Cory* was a fishing vessel with a raked stem, a rounded bilge to a full wood keel, and a transom stern (Figure 1). The hull below the main deck was subdivided by transverse bulkheads, enclosing from forward: the forepeak, engine room, 3 foamed/fibreglassed fish holds (2 forward and 1 aft), and a lazarette in which the hydraulic steering was located. The fish holds each had 1 access hatch and 2 manholes at deck level.[1]

The vessel was fitted with 2 fuel tanks that were located on the port and starboard sides of the engine room, and 3 fresh water tanks that were located at the stern. The vessel was propelled by 2 diesel engines, which transmitted power though a single gear box to an intermediate shaft and a tail shaft that ran through a shaft tunnel.[2]

The vessel was equipped with a hydraulic deck winch and a seine drum. The main mast, located near amidships, was rigged with a boom and fitted with a hydraulic topping lift and 2 single falls.

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1 On the occurrence voyage, the manholes were secured and the access hatches were open.

2 The shaft tunnel is a narrow compartment through which the propeller shaft of a vessel passes, from the after engine-room bulkhead through to the stern tube.

Figure 1. The *Miss Cory* in November 2016, outfitted for salmon purse seining (Source: Randy Hall, photographer)

The deckhouse contained the wheelhouse, master's cabin, galley, crew quarters, and the entrance to the engine room. The engine room was also accessible from the main deck on the starboard side. The wheelhouse contained navigation and communications equipment that included very high frequency / digital selective calling (VHF/DSC) radiotelephones, a depth sounder, a radar, an autopilot, a global positioning system (GPS), and a watch alarm.[3]

The vessel was fitted with 2 hydraulic bilge pumps in the engine room that were connected to the various compartments by steel piping. The vessel was also fitted with 2 electric bilge pumps in the shaft tunnel and 3 electric bilge pumps in the engine room, which were designed to operate automatically and discharge water overboard. A portable 110 volt AC electric pump was also available on board.

At the time of the occurrence, the *Miss Cory* was outfitted for herring purse seining (Appendix A).

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3 A watch alarm can be configured to sound at various intervals, requiring crew members to acknowledge the alarm. It is intended to ensure that crew members are awake during the watch.

1.3 History of the voyage

On 06 March 2017, at approximately 0600,[4] the *Miss Cory* departed Comox, British Columbia, with nearly full tanks of fresh water and fuel, and approximately 4 tons of ice in each forward hold. The vessel was manned by a master, an engineer, 2 deckhands, and a cook, and was headed for the fishing grounds off Cape Lazo (Appendix B). Prior to departure, the crew had replaced one of the electric pumps in the shaft tunnel. The inspection plate to the shaft tunnel located in the aft hold was left open so that the crew could monitor the pumps' performance and any ingress of water into the shaft tunnel.[5]

At approximately 0900, the *Miss Cory* located a school of herring near the water's surface; the school was estimated to be approximately 400 tons, in approximately 140 fathoms of water. The master of the *Miss Cory* contacted 1 of its pool partners,[6] the fishing vessel *Proud Venture*, and stated that the school being monitored[7] was large enough for both vessels to harvest.

At approximately 1100, soon after the Department of Fisheries and Oceans (DFO) declared the roe herring fishery open[8] (Appendix C), the *Miss Cory*'s crew set their seine around the school of herring and started drumming it back and pursing it up. In preparation to pump the fish out of the seine, the stern section of the net was lifted and held approximately 10 m above the deck, using the single fall at the end of the boom. By this time, the *Proud Venture* was alongside the *Miss Cory* in a bow-to-stern formation and was secured to the vessel's seine corkline (Figure 2). The *Miss Cory*'s power skiff, with 1 crew member on board, kept the vessel from overriding the seine and kept the 2 vessels apart.

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4 All times in this report are Pacific Standard Time (Coordinated Universal Time minus 8 hours).

5 The aft hold was not used to store fish.

6 Vessels that form a pool have agreed to work together and share equally in the catch.

7 The vessel monitored the school's movements while waiting for DFO to open the fishery at 1100.

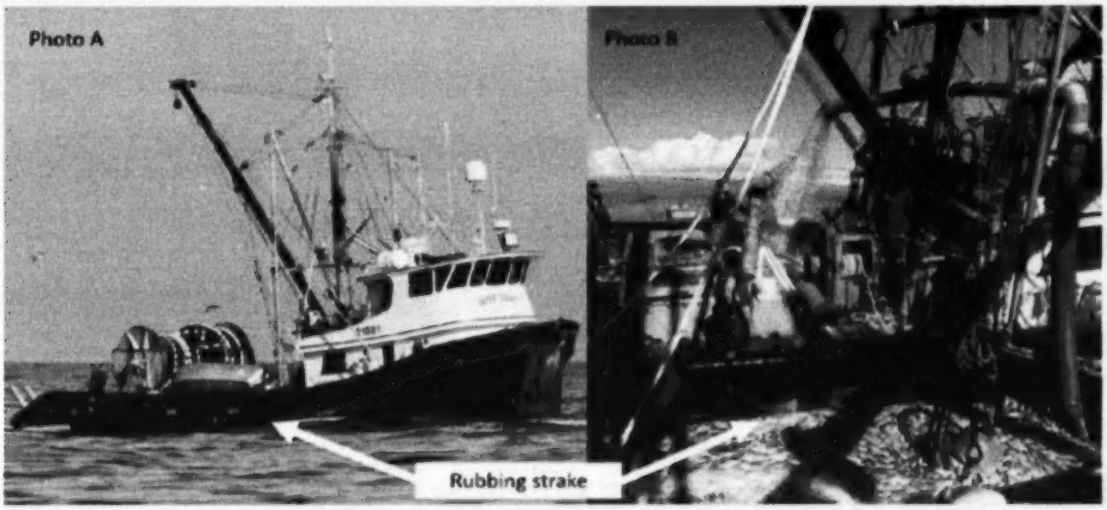
8 Department of Fisheries and Oceans Canada, Fishery Notice "FN 0177: FN0177-COMMERCIAL-Herring: Roe - Strait of Georgia – March 6, 2017 Update and Seine Fishery Opening."

Figure 2. The *Miss Cory* (right) and the *Pacific Joye* (left), with the *Proud Venture* between them. The *Miss Cory*'s power skiff is shown at the far right. (Source: Fisheries and Oceans Canada)

The *Proud Venture* then contacted the packer *Pacific Joye*, which was in the area; the *Pacific Joye* came alongside the *Proud Venture* at approximately 1230. The *Proud Venture* used its fish pump to transfer approximately 100 tons of herring, mostly from the top of the concentrated pocket of fish in the tightly pursed seine, into the *Pacific Joye*. At approximately 1345, after the *Proud Venture* finished loading the *Pacific Joye*, the *Miss Cory* developed a noticeable starboard list from the weight of the fish in the seine. To stabilize the vessel and reduce the list, approximately 40 tons of fish were loaded into the forward holds of the vessel, which submerged the vessel's rubbing strake (Figure 3). No other packing vessels were immediately available to assist the *Miss Cory*. At approximately 1500, the crew started transferring fish into the *Proud Venture*. By this time, the fish had settled to the bottom of the purse.[9] A section of hose was added to the pump and lowered to the bottom of the purse to access the fish.

[9] When the fish die, they settle to the bottom of the net, which increases the weight of the suspended load.

Figure 3. The rubbing strake on the *Miss Cory*, shown above the surface of the water while the vessel is voyaging (Photo A) and submerged while the vessel lists during operations (Photo B)



At approximately 1530, while fish were being pumped into the *Proud Venture*, the *Miss Cory* listed further to starboard. While monitoring the vessel's compartments, the crew of the *Miss Cory* detected water in the engine room and in the aft hold. The crew noted that the water level was rising rapidly and that the aft hold appeared to be approximately 50% to 75% full (Figure 4).

Figure 4. Water in *Miss Cory*'s aft hold

The master, along with the crew, attempted to transfer the fish pump into the aft hold to facilitate pumping out the water. The engineer, who had been in and out of the engine room a few times, re-entered the engine room to attend to the bilge pumps. The crew of the *Proud Venture* provided a portable pump, which was transferred to the *Miss Cory*'s engine room. The *Proud Venture*'s mate boarded the *Miss Cory* to assist with the situation.

The master of the *Miss Cory* then lowered the stern section of the net into the water, which momentarily reduced the list of the vessel and increased the size of the purse. The crew repositioned the boom over the aft hold and used it to help lower the fish pump into the hold. The master and crew attempted to lower the fish pump into the aft hold, but were unsuccessful because the diameter of the pump was marginally larger than the aft hold opening.

Shortly after the stern section of the net was lowered into the water, the remaining fish settled back to the bottom of the seine, and the *Miss Cory* listed heavily to starboard. The mate of the *Proud Venture*, who was assisting on the deck of the *Miss Cory*, noticed the

increased list, and the starboard deck submerged to approximately 300 mm below the waterline. The mate alerted the crew to abandon the vessel and asked the *Proud Venture*'s deckhand to bring the *Proud Venture*'s skiff over to the port side of the *Miss Cory* to make it easier to abandon the vessel.

At approximately 1545, 3 of the *Miss Cory*'s crew members and the mate of the *Proud Venture* abandoned the *Miss Cory* by jumping onto the *Proud Venture*'s skiff. The *Miss Cory*'s fourth crew member was still on board the *Miss Cory*'s skiff towing the vessels apart. The crew attempted to alert the fifth crew member, the engineer, who was still in the engine room as they abandoned the *Miss Cory*, but the vessel continued to capsize and rapidly sank. The vessel was not recovered. The engineer was subsequently reported missing.

1.4 Search and rescue

The *Proud Venture* reported the incident to the Marine Communications and Traffic Services Centre at Prince Rupert, British Columbia, which in turn reported it to the Joint Rescue Coordination Centre in Victoria. Four vessels and a search and rescue (SAR) aircraft conducted a search in the area for the missing crew member. The search was terminated at approximately 1910, when daylight ended. The survivors were transported to Comox, British Columbia, on board the *Proud Venture*, which was escorted by the Canadian Coast Guard lifeboat *Cape Cockburn*.

1.5 Environmental conditions

At the time of the occurrence, the skies were partly cloudy, the winds were from the southeast at 15 knots, and there was a 0.2 m swell. The air temperature was 5 °C, and the sea temperature was 8 °C.

1.6 Damage to the environment

The vessel sank with approximately 7500 L of diesel fuel and a small quantity of engine oil on board. An unspecified amount of diesel was released into the environment at the time of the occurrence.

1.7 Vessel certification

The *Miss Cory* had its last quadrennial inspection by Transport Canada (TC) on 28 June 2016 at Prince Rupert, British Columbia. An inspection certificate was issued for operation as a Near Coastal Voyage, Class 1 (home-trade voyage, class II) vessel, with a crew of 4.

The inspection noted the absence of operating and emergency procedures, which are required to be provided to the crew by the authorized representative (AR), as per the *Canada Shipping Act, 2001* (CSA 2001).[10] The inspection also noted that the vessel's emergency position indicating radio beacon (EPIRB) was not registered. These 2 deficiencies were not

[10] *Canada Shipping Act, 2001* (S.C. 2001, c. 26, last amended 22 June 2017), section 106.

addressed by the owner. Several other minor deficiencies were also identified, most of which were corrected by the owner.

1.8 Personnel certification and experience

The master of the *Miss Cory* held a certificate of service as master of a fishing vessel with a gross tonnage (GT) of not more than 100. The master had worked on the *Miss Cory* since the summer of 2016 and had 45 years of experience on fishing vessels. The master also held a Radio Operator's Certificate – Maritime Commercial and had taken Marine Emergency Duties training.

The engineer had 34 years of experience on fishing vessels. This occurrence was the first time the engineer had worked on board the *Miss Cory*. The 2 deckhands and the cook had completed the required Marine Emergency Duties courses.

To ensure that the crew was familiar with the vessel, the owner provided the master and engineer with vessel familiarization training while the vessel was moored in Comox, British Columbia.

1.9 Vessel maintenance and modification

The vessel was fitted with a new deckhouse in 1993, and the fish holds were tanked (converted from a dry pack to a wet pack) in 1996. In 2012, the vessel was purchased by its current owner. At that time, the vessel underwent a stability assessment and a 3800 kg permanent ballast was added to the vessel. TC then approved the vessel's stability booklet.

The vessel underwent annual maintenance at a shipyard in Prince Rupert, British Columbia. In May 2016, at the shipyard, the sides of the hull were caulked[11] from the keel up to the waterline.[12] In February 2017, the master caulked the decks, and an independent contractor added fibreglass to the aft hold.

Before the fishery opened in March 2017, one of the electric bilge pumps located in the shaft tunnel was replaced.

1.10 Lifesaving equipment

Lifesaving equipment on board the *Miss Cory* included 6 lifejackets, 5 immersion suits, an inflatable life raft fitted with a hydrostatic release, a power skiff, 2 lifebuoys, 12 pyrotechnic distress flares, and 1 float-free EPIRB.

The vessel capsized and sank too quickly for the crew to don lifejackets or immersion suits; however, the deckhands and engineer wore personal flotation devices while working on

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11 Sealed with a waterproof filler and sealant.

12 When the vessel is at loaded condition, its waterline is slightly below the rubbing strake.

deck. The EPIRB was not registered by the owner and did not float free or activate when the vessel sank.

1.10.1 Registration of emergency position indicating radio beacons

The Canadian Beacon Registry is an integral part of the SAR satellite system designed to provide distress alert and location data to SAR authorities. The Registry is part of the Canadian Mission Control Centre is co-located with the Canadian Mission Control Centre at Canadian Forces Base Trenton, for use by responders in SAR operations.[13] It is mandatory for all EPIRBs to be registered with the Canadian Beacon Registry.[14] Online access to the Canadian Beacon Registry is available to all owners of 406 MHz emergency beacons so that they can register new emergency beacons or update their existing information.

When an EPIRB is activated, the signal is sent to 2 systems used in distress and safety incidents worldwide: the Geostationary Orbiting Search And Rescue Satellites and the Cospas-Sarsat system.

An EPIRB signal picked up by the Geostationary Orbiting Search And Rescue Satellites allows SAR resources access to registered data within minutes. This provides them with critical information (owner contact information, emergency contact information, vessel characteristics and equipment), allowing them to respond quickly and appropriately to a given situation.

When the Cospas-Sarsat system picks up a signal, it pinpoints the beacon's location and relays that information to SAR resources, but this system can take longer, up to 90 minutes.

However, if an EPIRB is unregistered, SAR resources do not have access to this information. A registered EPIRB helps SAR resources provide better or faster assistance to people in distress; it might help to establish where the distress situation is located (the location might otherwise be unavailable), what to search for, how many people need assistance, what type of help might be needed, and other ways to contact the owner.

This information is also useful to authorities to validate distress alerts by eliminating false alarms, which divert SAR resources away from genuine emergencies. In many cases, SAR resources can use a simple phone call to identify a vessel that has inadvertently set off an alarm.

Because the *Miss Cory* was not recovered, the TSB was unable to determine why the EPIRB did not float free and activate. However, the device was not registered and therefore was not set up to permit immediate identification or to help prevent false alerts.

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13 Department of National Defence, "Canadian Beacon Registry – Welcome," at https://www.cbr-rcb.ca/cbr/presentation/other_autre/index.php?lang=en (last accessed on 04 June 2018)

14 Transport Canada, SOR/2000-265, *Ship Station (Radio) Technical Regulations* (last amended 13 July 2017), section 26.

Ensuring that EPIRBs are registered and that the registration information is updated regularly can make it easier for SAR personnel to find vessels in the event of a distress situation.

1.11 Emergency preparedness

TC requires fishing vessel masters to ensure that each crew member becomes familiar with assigned duties that are vital to safety, and can perform those duties effectively.[15]

WorkSafeBC requires that crew members be trained on the location and use of safety equipment, and that they be assigned duties for all emergency situations. Fishing vessel masters are also required to conduct emergency drills before the fishing season begins.

Before departing Comox, the *Miss Cory*'s crew and master discussed the muster list and emergency duties but did not practise them. From the dock at Comox, the deckhands observed drills conducted by Fish Safe[16] on board other vessels moored in the vicinity, which were conducted as part of the Herring Drills Days 2017 outreach program that coincided with the start of the herring fishery.

1.12 Fishing vessel stability

1.12.1 Transport Canada requirements

At the time of the occurrence, Part I of the *Small Fishing Vessel Inspection Regulations* (SFVIR)[17] applied to fishing vessels with a length of not more than 24.4 m and not more than 150 GT, such as the *Miss Cory*. Under these regulations, vessels of closed construction, more than 15 GT, built on or after 06 July 1977, and engaged in fishing for herring or capelin, were required to have approved stability data on board. This also applied to vessels that had been converted to herring fishing or had undergone any modifications that adversely affected its stability characteristics.[18] The regulations also required that a booklet be placed on board the vessel which provided information to the master regarding the stability characteristics of the

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15 Transport Canada, SOR/2007-115, *Marine Personnel Regulations* (last amended 03 July 2017), section 206.

16 Fish Safe is an industry-designed and implemented fishing safety organization. Its mandate is to provide safety programs and tools relevant to fishing so that fishermen can take ownership of safety. Participation in programs is voluntary.

17 As of 13 July 2017, the *Fishing Vessel Safety Regulations* have replaced portions of the *Small Fishing Vessel Inspection Regulations*. The new regulations have similar requirements to the previous ones, requiring any vessel that has a hull length of more than 9 m and has undergone a major modification or a change in activity that is likely to adversely affect its stability to undergo a stability assessment by a competent person. The new regulations, however, make reference to the requirements of the *International Code on Intact Stability* (IS Code 2008) as opposed to TP 7301 (Stability, Subdivision and Load Line Standards) and require a stability notice to be posted on board the vessel in a conspicuous location.

18 Although the *Miss Cory* was built in 1956, the vessel required a stability assessment because it had undergone modifications that affected its stability characteristics.

vessel and contained appropriate information relative to loading in the various conditions specified by the regulations.[19]

The SFVIR did not include any details regarding the specific assumptions that must be made with respect to the weight distribution of fuel, water, and fish, or how the fish are brought on board. The typical practice when calculating stability is to assume that the catch has been loaded and stowed, and the vessel is ready for voyaging.

TC published the *Stability, Subdivision and Load Line Standards* (TP 7301) in 1975 to provide guidance and criteria for the approval of stability information required by the SFVIR. The only guidance the standards provide regarding the assumed weight distributions for stability calculations is that it is the owner's responsibility to ensure that the stability conditions presented in the stability booklet accurately reflect the vessel's loading conditions and modes of operation.[20]

According to the standards, the owner and the master of a vessel are responsible for ensuring that a proper measure of stability is maintained for all loading conditions.[21] The standards require a copy of the approved stability booklet to be carried on board and state that it should contain sufficient information to enable the master to assess any new load conditions in addition to those presented in the booklet.[22]

1.12.2 Periodic verification of stability data

Recognizing that vessels undergo modifications over time, the International Convention for the Safety of Life at Sea (SOLAS)[23] and TC[24] have a requirement that, at intervals not exceeding 5 years, and under certain conditions, passenger vessels must undergo surveys to verify any changes in lightship weight. If a deviation falls outside allowable limits, the vessel is required to be re-inclined. However, this requirement does not apply to fishing vessels, which do not fall under SOLAS but are subject to frequent modifications and design changes to suit different fisheries. These changes frequently adversely affect a vessel's stability.

Of the 86 vessels that were licensed by DFO to participate in the 2017 Strait of Georgia roe herring fishery, 39 actually fished, including the *Miss Cory*. The TSB examined the stability booklets of all the vessels that fished, and determined that

- 17 booklets were over 30 years old;

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19 Transport Canada, C.R.C. c. 1486, *Small Fishing Vessel Inspection Regulations*, subsection 29(7), as in effect at the time of the occurrence. This provision was repealed as of 13 July 2017, when the new *Fishing Vessel Safety Regulations* came into force.

20 Transport Canada, TP 7301, *Stability, Subdivision and Load Line Standards* (January 1975), STAB 1, Section 3 (iv).

21 Ibid., STAB 1, section 3 (xvii).

22 Ibid., STAB 1, Appendix A, section 2.

23 SOLAS, Chapter II-1, Part B, Regulation 22.

24 Transport Canada, TP 10943, *Passenger Vessel Operations and Damaged Stability Standards*, 2nd edition (October 2007), Part III, Section 20.

- 12 booklets were between 20 and 30 years old;
- 10 booklets did not reflect the vessel's herring operation; and
- None of the booklets contained an assessment of loading conditions for boom operations.

1.12.3 Stability documentation for the Miss Cory

The *Miss Cory* had been modified several times over its lifetime. Modifications included replacing and enlarging the main deckhouse and adding a seine drum, tilt stern, and tanked fish holds.

On 11 January 2013, a trim and stability booklet for the *Miss Cory*, as fitted and equipped for salmon purse seining, was submitted by a naval architect on behalf of the owner to TC for approval. On 13 February 2013, TC completed its review and found the booklet to be in compliance with the applicable stability criteria at the time. TC approved the booklet but also sent a letter to the naval architect and owner notifying them that it had been observed that the vessel carried a lifting device (boom) on the aft deck and that, if this lifting device was used for cargo operations, the vessel's stability needed to be assessed while the lifting device was being operated. TC also stated that, because no loading condition had been studied for operating the lifting device either on the fishing grounds or in port alongside, the lifting device could only be operated on the vessel with a further stability assessment.

The stability booklet contained some instructions and notes to the master, such as:

- The boom (lifting device) is to be fixed amidships during voyages. The boom should be lowered to its lowest possible position during heavy weather.
- All weights in this stability booklet are generally considered to be on the centreline of the vessel. Care and attention must be paid to keeping weights centred and to minimize the list.
- The use of larger, heavier, or more gear than has been analyzed in the preparation of this booklet must not be undertaken until the effects on stability have been thoroughly assessed.
- Modifications to the vessel for use in a fishery different than the one reviewed in this book must not be undertaken until the effects on stability characteristics have been fully assessed.
- Under no circumstances is the aft hold to be loaded.
- If the change in lightship is greater than 2% of the lightship shown in this book, the vessel must be completely re-evaluated, including inclining experiment.

At the time of the occurrence, the vessel was outfitted for herring purse seining rather than salmon purse seining. There are some differences in the operational procedures for these two fisheries. This meant that some of the calculations set out in the stability booklet (e.g., the weight of the net and the weight of the skiff) did not match the current fishing operations.

1.12.4 WorkSafeBC requirements

With respect to vessel stability, the WorkSafeBC *Occupational Health and Safety Regulations* require that all fishing vessels be maintained in seaworthy condition[25] and that the owner of a fishing vessel provide documentation on board that describes vessel stability.[26]

The guidelines corresponding to these regulations[27,28] clarify that, when determining seaworthiness, a number of factors must be considered, including the stability of the vessel. The guidelines also offer further explanatory information such as:

- Owners and masters are advised to refer to the regulations, policies, and best practices established by TC and have their vessels' stability assessed by a naval architect.
- Vessel stability characteristics will change over the life of the vessel; the accumulation of weight over the life of the vessel will likely cause a vessel to get heavier, and its centre of gravity to rise, thereby decreasing its stability.
- A common method of evaluating freeboard that is pertinent for vessels of open construction is the use of a load mark.
- Stability documentation must provide meaningful and detailed information on vessel characteristics and include instructions on how to perform vessel operations without impairing vessel stability.
- On-board documentation should contain information relative to loading under each of the conditions in the stability booklet.
- Owners should consider including a load chart, load matrix, loading condition sheet, electronic loading software or other similar instruction as part of the on-board documentation.
- On-board documentation must accurately reflect the vessel's typical loading condition and operations.
- The documentation should clearly state that it is unsafe for the vessel to sail if it is loaded outside of its stability limitations.
- The documentation describing the stability characteristics of the vessel must be presented in a format that is readily understandable by the end user.

According to the guidelines, when WorkSafeBC conducts inspections and investigations, it will evaluate whether the vessel has been provided with meaningful and clear stability documentation. WorkSafeBC will also confirm that the information in the manual describes

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25 Government of British Columbia, B.C. Reg. 296/97, *Occupational Health and Safety Regulations* (last amended 01 August 2017), Part 24: Part 24: Diving, Fishing and Other Marine Operations, Fishing Operations, General Requirements, paragraph 24.70(a).

26 Ibid., paragraph 24.72(b).

27 WorkSafeBC, *Prevention Manual* (2010), Part 24: Diving, Fishing and Other Marine Operations, paragraphs R24.70-1 and R24.72-1.

28 WorkSafeBC, *Guidelines for Workers Compensation Act*, Part 24: Diving Operations, General Requirements, paragraphs G24.70 and G24.72.

the vessel's current operating condition and contains the elements outlined in the guidelines. WorkSafeBC does not have an official approval process for on-board stability documentation.[29]

1.12.5 Fisheries and Oceans Canada requirements

DFO's 2017 Pacific Region Integrated Fisheries Management Plan for Pacific Herring reminded masters that, under the CSA 2001, all vessels fishing or packing herring were required to have a valid stability booklet on board the vessel. The booklet is intended to provide guidance to the vessel's crew, so that they may safely fish within the limitations of their vessel.

DFO licensed 86 seine fishing vessels to fish for Pacific herring during the 2017 season. Of the 86 vessels, given age and length exemptions, 45 were required to have a TC-approved stability booklet on board.

1.12.6 Assessment of stability while using the boom

To determine the effects of using the boom on the *Miss Cory*'s stability while purse seining, the TSB contracted the services of a naval architect. The data from the vessel's stability booklet were used to assess the vessel's stability while lifting over the side, based on 2 conditions that represented the condition of the *Miss Cory* at the time of the capsize:

1. Full consumables, no skiff, forward hold loaded, aft hold empty.
2. Full consumables, no skiff, forward hold loaded, aft hold 75% full.

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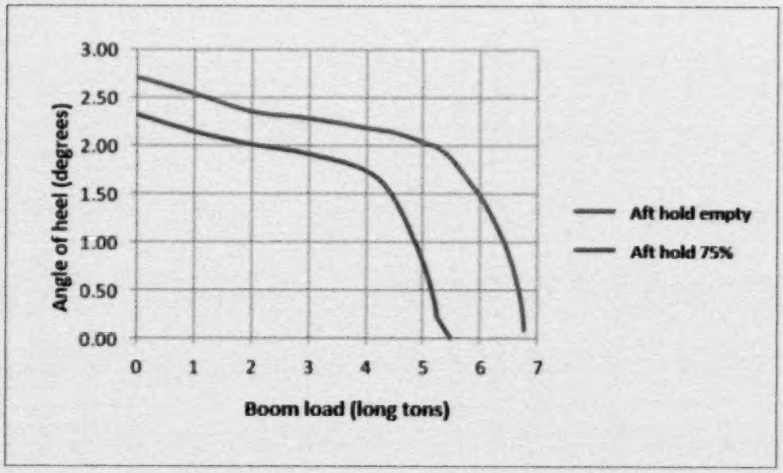
[29] WorkSafeBC does not have jurisdictional competence to review the adequacy of the documentation and considers approving documentation for each vessel to be impractical.

Figure 5. Limit of boom load (Image: MerLion Marine Services, with TSB annotations)

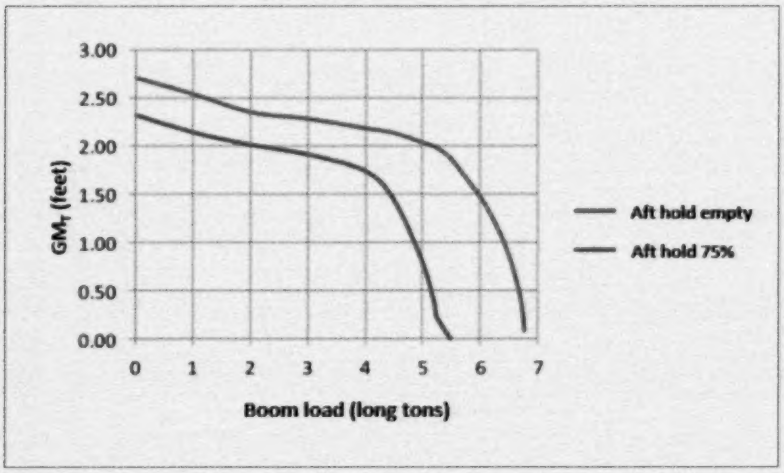


With the given parameters, it was calculated that the vessel would capsize at a boom load of 6.76 long tons with the aft hold empty, and at a boom load of 5.26 long tons with the aft hold 75% full. Figure 5 shows the angle of heel with increasing boom loads for the 2 conditions.

As the boom load increases, the value of the transverse metacentric height (GM_T)[30] decreases in a virtually linear fashion until a certain point is reached, at which point the GM_T decreases exponentially (Figure 6).

[30] The transverse metacentric height (GM_T) is a measurement of the initial static stability of a floating body. It is calculated as the distance between the centre of gravity of a ship and its metacentre. A larger metacentric height implies greater initial stability against overturning.

Figure 6. Transverse metacentric height (GM_T) with increasing boom load (Image: MerLion Marine Services, with TSB annotations)



Based on the assessment conducted by the naval architect, the TSB was able to determine the effects of lifting with the boom on the stability of the *Miss Cory*. The conclusions from the assessment are as follows:

1. The angle of heel varies directly with increasing boom load up to a point, and then increases rapidly to the point of capsizing.
2. With an assumed boom load of 5 long tons, a vessel with the aft hold empty has more than twice the range of stability when compared to a vessel with an aft hold that is 75% full.
3. The value of GM_T varies directly with the boom load up to a point, and then decreases rapidly.

The assessment demonstrated that as the boom load increases, the value of GM_T decreases and the angle of heel increases in a nearly constant fashion until a certain load is reached, at which point the GM_T decreases exponentially, corresponding with a rapidly increasing heel.

1.13 Situational awareness and workload

The master is primarily responsible for the safety of the vessel and for all those on board. As required by the CSA 2001, "[i]f the master of a vessel is informed of a safety hazard, the master shall, unless the master determines that the hazard does not exist, take reasonable measures to protect the vessel and persons on board from the hazard, including eliminating it if feasible."[31]

To maintain the safety of a vessel and all those on board, masters must maintain situational awareness of all the operations on that vessel and the manner in which they are conducted.

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31 *Canada Shipping Act, 2001* (S.C. 2001, c. 26, last amended 02 June 2017), subsection 109(2).

Masters must be alert and must constantly monitor and process information on and around the vessel. Attention and vigilance is necessary for masters to perceive elements in the environment and adjust their actions accordingly.[32]

Situational awareness is defined as the perception of elements in the environment, the comprehension of their meaning, and the projection of their status in the future.[33] Several factors can influence these 3 levels of situational awareness, such as attention, the ability to process information, and workload.[34] All 3 levels involve several stages of information-processing where shortcomings may occur and which may result in incomplete or inadequate situational assessments.

If a vessel master is required to perform multiple tasks that require the same information-processing resources, and one task suddenly requires more attention from that resource, performance on the remaining tasks could be hampered.[35] For example, performing a task that is difficult to complete would increase demands on the ability to process information, increase workload, and reduce the available capacity for other tasks that require information processing, such as maintaining vigilance and sustained attention.[36] High task demands are assumed to be more capacity-draining than low task demands because of the need to make more frequent and rapid decisions.

Mental workload and situational awareness are intertwined; both use and compete for the same limited information processing capabilities. In some instances, a high workload can result in increasing situational awareness, while in other cases it can lead to a lower degree of situational awareness by reducing the capacity to perceive elements in the environment.[37]

1.14 Safety guidance for fishing vessels

In British Columbia, under WorkSafeBC's occupational health and safety regulations, the master is responsible for identifying existing and potential hazards and establishing safety procedures to mitigate the associated risks.[38] TC has similar regulations that place the

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32 D. LaBerge, *Attentional Processing: The Brain's Art of Mindfulness* (Harvard University Press, 1995).

33 M. R. Endsley, "Design and Evaluation for Situation Awareness Enhancement," in: *Sage Journals - Proceedings of the Human Factors Society: 32nd Annual Meeting*, Vol. 32, Issue 2 (1988), pp. 97–101.

34 J. A. Wise, V. D. Hopkin, and D. J. Garland, *Handbook of Aviation Human Factors Second Edition* (CRC Press, 2016), Chapter 12: Situation Awareness in Aviation Systems, Section 1.

35 C. D. Wickens, "Multiple resources and performance prediction," in: *Theoretical Issues in Ergonomic Science*, Vol. 3, No. 2 (2002), pp. 159–177.

36 C. D. Wickens, Technical Report EPL-81-3/ONR-81-3, "Processing Resources in Attention, Dual Task Performance, and Workload Assessment" (Office of Naval Research Engineering Psychology Program 1981).

37 G. Salvendy, *Handbook of Human Factors and Ergonomics* (John Wiley & Sons, 2012), Chapter 8: Mental Workload and Situation Awareness, pp. 243–248.

38 WorkSafeBC, *Guidelines for Occupational Health and Safety*, Part 24: Diving, Fishing and Other Marine Operations, paragraph G24.69 – Fishing operations – Determining who is the employer.

responsibility of developing procedures, and the safe operation of the vessel, on the AR.[39] The resulting safe work practices help to ensure that masters and crew have the knowledge and the necessary information to make sound decisions in any operating condition.

There is some guidance available to help the AR develop safe work practices.

1.14.1 Transport Canada

Under the CSA 2001,[40] ARs are required to provide the vessel with procedures for how to safely operate the vessel and deal with emergencies.

Under the *Marine Personnel Regulations*,[41] ARs are required to provide the vessel master with written instructions that will ensure that, before being assigned any duty, each member of the complement becomes familiar with shipboard equipment, operational instructions and assigned duties, and can effectively perform duties that are vital to safety or the mitigation of pollution.

Under the *Fishing Vessel Safety Regulations* (FVSR),[42] ARs must establish and use written safety procedures that familiarize persons on board a fishing vessel with:

- the location of safety equipment and how to use it
- measures to be taken to protect persons on board
- in the case of purse seining operations, how to quickly release loads that can be activated in an emergency
- measures to prevent fires and explosions on the vessel
- measures to maintain watertightness, and to prevent interior spaces from flooding
- measures to ensure safe loading, stowage, and catch unloading, baits and consumables
- how to operate towing and lifting equipment, and measures to prevent overloading the vessel

To help ARs meet the above responsibilities, TC has created operation and safety procedure templates that can be adapted to the needs of individual vessels. These include checklists and forms for managing operations and recording crew training or emergency drills.

1.14.2 Herring Industry Advisory Board

In 2015, the members of the Herring Industry Advisory Board, in collaboration with Fish Safe, developed and distributed a best practices document for the British Columbia herring

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39 *Canada Shipping Act, 2001* (S.C. 2001, c. 26, last amended 22 June 2017), Part 4, subsection 106(1).

40 Ibid., section 106: Authorized Representatives.

41 Transport Canada, SOR/2007-115, *Marine Personnel Regulations* (last amended 03 July 2017), section 206.

42 Transport Canada, C.R.C., c. 1486, *Fishing Vessel Safety Regulations* (last amended 13 July 2017), Division 1: General Requirement, subsection 3.16: Safety Procedures.

fishery entitled *Herring Food and Bait Best Practices*.[43] The roe and food and bait herring fisheries have similar operating procedures, but they are not identical as the markets for the fish are different. The recommended practices for the food and bait herring fishery include

- ensuring the crew understand the stability limits of the vessel;
- developing and training crew on emergency procedures for releasing a set;
- when making a set, taking available packing capacity into consideration;
- keeping sets under 100 tonnes;
- tying the net off at deck to keep the weight of the net low;
- minimizing the time fish are held in the net, to ensure quality and safety;
- releasing some fish before drying[44] up the net, if too many fish are caught;
- keeping hatches, manholes, and doors that are not in use secured and/or closed; and
- participating in industry programs (e.g., Fish Safe's Safest Catch program).

The *Miss Cory's* crew was not provided with any formal routine or emergency operation procedures, nor was the master aware of the *Herring Food and Bait Best Practices*.

1.14.3 WorkSafeBC

In 2012, WorkSafeBC, in collaboration with Fish Safe, updated its manual *Gearing Up for Safety – Safe Work Practices for Commercial Fishing in British Columbia*. The manual addresses many common safety and health hazards in the commercial fishing industry. It emphasizes emergency preparedness, safe operating procedures, safety equipment, and hazards related to the type of gear on board. With regard to purse seining, the manual states that pumping gear must be able to reach the bottom of the concentrated pocket of fish because drying up creates deadweight that can cause stability problems.[45] WorkSafeBC also audits fishing vessels where possible to evaluate compliance with health and safety requirements.

1.14.4 Fish Safe Safest Catch Program

The Safest Catch Program is a safety program driven by the commercial fishing industry. The tools it provides to the commercial fishing industry are designed by fishermen for fishermen, with the goal of promoting ownership of safety on board fishing vessels. Fishermen trained as safety advisors give masters and crew an initial on-board workshop to help them develop familiarization protocols, emergency drills, and safety procedures manuals.

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43 Fish Safe, *Herring Food and Bait Best Practices* (2015), at http://www.fishsafebc.com/blog/2015/9/30/herring-best-practices (last accessed 05 June 2018).

44 Drying up is a process where the net is progressively brought on board to minimize the portion of the net containing the fish that is in the water.

45 WorkSafeBC, *Gearing Up for Safety – Safe Work Practices for Commercial Fishing in British Columbia* (2012), at https://www.worksafebc.com/en/resources/health-safety/books-guides/gearing-up-for-safety-safe-work-practices-for-commercial-fishing-in-british-columbia?lang=en (last accessed 05 June 2018).

The program also helps commercial fishermen develop a vessel-specific safety management system (SMS) that is compliant with current Transport Canada Marine Safety and Security requirements relating to the content of an SMS, even though fishing vessels are not currently required to have an SMS in place.

In its current form, the Safest Catch Program delivers introductory training to crews on their own fishing vessels. In the future, the program will

- carry out periodic follow-up monitoring with fishing vessel crews;
- encourage fishermen to understand how to manage and take ownership of safety as an integral part of their normal fishing operations;
- help fishermen understand that shipboard safety does not only consist of buying survival equipment and doing a single initial emergency drill – it must also be practiced periodically so that the handling of lifesaving and firefighting equipment becomes a reflex; and
- encourage fishermen to adopt a formal risk assessment procedure whereby the master and crew identify all risks and hazards associated with their particular fishing operations (slips and falls, person overboard, becoming caught in or hitting fishing gear, etc.), and adopt all appropriate preventive methods to mitigate those risks.

At the time of the occurrence, the *Miss Cory* had not participated in the Safest Catch Program.

1.15 Safety Issues Investigation into Fishing Safety in Canada

In August 2009, the TSB undertook an in-depth safety issues investigation into fishing vessel safety in Canada. The final report, released in June 2012, provides a national view of safety issues in the fishing industry, revealing complex relationships and interdependencies among these issues. The Board identified the following significant safety issues requiring attention: stability, fisheries resource management, lifesaving appliances, training, safety information, cost of safety, safe work practices, regulatory approach to safety, fatigue, and fishing industry statistics.[46] These 10 issues form part of the context of commercial fishing work in Canada.

1.16 Outstanding recommendations

In 1990, the TSB identified a deficiency related to the adequacy of stability information in an occurrence involving the small fishing vessel *Le Bout De Ligne*, and recommended that

> The Department of Transport establish guidelines for stability booklets so that the information they contain is presented in a simple, clear, and practical format for end-users.
>
> **TSB Recommendation M94-33**

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[46] TSB Safety Issues Investigation Report M09Z0001, *Safety Issues Investigation into Fishing Safety in Canada*, at http://www.tsb.gc.ca/eng/rapports-reports/marine/etudes-studies/m09z0001/m09z0001.asp (last accessed 05 June 2018).

In July 2016, in response to TSB Recommendation M94-33 and numerous others relating to fishing vessel stability, TC published in the *Canada Gazette*, Part II, regulations to create the new *Fishing Vessel Safety Regulations* and replace the *Small Fishing Vessel Safety Regulations*. Under the new *Fishing Vessel Safety Regulations*, newly built vessels greater than 9 m in length are required to undergo stability assessments and have stability booklets produced. The response to this TSB recommendation is currently assessed as Satisfactory in Part.[47]

Following an occurrence in 2002, in which the seiner *Cap Rouge II* capsized in the Strait of Georgia, British Columbia, and 5 people drowned,[48] the Board recommended that

> The Department of Transport, in collaboration with the fishing community, reduce unsafe practices by means of a code of best practices for small fishing vessels, including loading and stability, and that its adoption be encouraged through effective education and awareness programs.
>
> **TSB Recommendation M03-07**

TC's response to this recommendation is currently assessed as Satisfactory in Part. While TC is making progress in issuing regulations for fishing vessels, regulations alone cannot remedy the safety deficiency that was identified during this investigation. Unsafe work practices persist in the fishing industry despite an overall understanding of safe work practices. Until a code of best practices is developed and implemented by the Canadian fishing industry, this recommendation will remain active.

Following an occurrence in 2015,[49] in which the hake trawler *Caledonian* capsized and sank, resulting in the death of 3 crew members, the Board recommended that

> The Department of Transport establish standards for all small fishing vessels that have had a stability assessment to ensure their stability information is adequate and readily available to the crew.
>
> **TSB Recommendation M16-02**

TC stated that it proposed to take action to provide stability notice templates and guidelines and how to complete them, to reissue Ship Safety Bulletin 01/2008, and to renew emphasis on stability booklets during inspections. Once fully implemented, TC's actions should ensure that, for this category of small fishing vessels, fishermen will have access to stability information that is current and continually updated to reflect any changes to the vessel and/or its operations, and that is provided in a user-friendly format (stability notices). The Board considers the response to this recommendation to show Satisfactory Intent.

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47 A Satisfactory in Part rating is assigned if the planned action or the action taken will reduce but not substantially reduce or eliminate the deficiency, and meaningful progress has been made since the recommendation was issued. The TSB will follow up with the respondent as to options that could further mitigate the risks associated with the deficiency. The TSB will reassess the deficiency on an annual basis or when otherwise warranted.

48 TSB Marine Investigation Report M02W0147.

49 TSB Marine Investigation Report M15P0286.

1.17 TSB Watchlist

The TSB Watchlist identifies the key safety issues that need to be addressed to make Canada's transportation system even safer.

The Watchlist highlights that regulations alone are not enough and that there is a need for concerted and coordinated action by federal and provincial authorities and by leaders in the fishing community to improve the safety culture in fishing operations, recognizing the interaction of safety deficiencies.

Commercial fishing safety will remain on the TSB Watchlist until

- new regulations are implemented for commercial fishing vessels of all sizes;
- user-friendly guidelines regarding vessel stability are developed and implemented to reduce unsafe practices;
- there is evidence of behavioural changes among fishermen regarding the use of personal flotation devices, EPIRBs, and survival suits, as well as of on-board safety drills and risk assessments being carried out; and
- there is concerted and coordinated action by federal and provincial authorities, leaders within the fishing community, and fishermen themselves to put in place strong regional initiatives and develop a sound safety culture in the fishing community.

1.18 Previous occurrences

The TSB has previously investigated several small fishing vessel occurrences where issues related to stability and unsafe operations while loading catch have been identified.

M05W0141 – On 26 July 2005, the fishing vessel *Ocean Tor* capsized and sank west of Cape Flattery, Washington. The vessel listed heavily and subsequently capsized when transferring a load of fish from the nets into the fish holds. Two crew members lost their lives.

M06N0082 – On 01 November 2006, the small fishing vessel *Cape Fin-Tose* capsized and sank while pumping mackerel from a purse seine belonging to the *Cape Jeduse*, which was close alongside the *Cape Fin-Tose*. The crew members managed to abandon the vessel into a skiff tied alongside the *Cape Jeduse*.

M09N0031 – On 12 September 2009, the small fishing vessel *Sea Gypsy Enterprises* took on water, downflooded, and sank off Cape Spear, Newfoundland and Labrador. Two crew members drowned.

2.0 *Analysis*

The investigation determined that progressive downflooding[50] and a raised centre of gravity caused by an increase in the suspended weight on the vessel's boom affected the *Miss Cory*'s stability, causing the vessel to capsize.

This analysis examines the crew's response to the downflooding, the effect that lifting or suspending weight using a vessel's boom has on the stability of the vessel, and the adequacy of fishing vessel stability information.

2.1 *Factors leading to the capsizing and loss of life*

A delay in the availability of a packing vessel resulted in a large set of fish being tightly pursed in the seine along the *Miss Cory*'s starboard side for several hours. Unable to swim freely, many of the fish died, and as they sank and settled to the bottom of the pursed seine, their weight increased the load on the net. The load transferred to the starboard side of the *Miss Cory* and to the top of the boom, raising the vessel's centre of gravity and causing the vessel to increasingly list to starboard. This, together with a reduced freeboard caused by loading the forward holds, resulted in the vessel listing to the point where the rubbing strake was submerged in water.

Because the *Miss Cory* sank, it was not possible to conduct a structural examination of the vessel; consequently, the investigation could not establish the precise condition of the hull and deck at the time of the occurrence. However, it is not unusual for a 60-year-old wooden fishing vessel to experience some leakage. Therefore, because the *Miss Cory* was caulked only up to the waterline, it likely experienced some leakage, which may have caused water to enter the vessel from behind the rubbing strake when the vessel listed and the rubbing strake was submerged. From there, the water likely made its way through the skin of the hull and into the shaft tunnel.

The safety of a vessel at sea depends on maintaining watertight integrity. It is therefore important to take measures such as closing inspection plates, access hatches, and other openings to prevent the ingress of water and progressive downflooding.

Just before the *Miss Cory* capsized, the crew detected water in the aft hold, which was filling from the open inspection plate of the shaft tunnel and rising rapidly. The ingress of water, which filled approximately 50% to 75% of the aft hold, negatively affected the vessel's stability.

Attempts to dewater using the vessel's pumps were unsuccessful, because they could not cope with the water ingress. In the moments before the capsizing, the master and deck crew attempted to use the boom to transfer the fish pump into the aft hold in order to assist with

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[50] Downflooding means any flooding of the interior of any part of the buoyant structure of a unit through openings which are not closed watertight or weathertight, as appropriate, in order to meet the intact or damage stability criteria.

dewatering. To do this, they lowered the suspended stern section of the net into the water, thereby temporarily increasing the size of the purse.

After the net was lowered into the water, the weight of the net and the dead fish was transferred back to the boom when the fish settled to the bottom of the purse. The weight on the boom, along with the progressive downflooding of the compartments in the vessel (particularly the aft hold), caused the vessel to heel over and capsize.

The master and crew were focused on dewatering the vessel, particularly trying to fit the fish pump into the aft hold, and no one noticed the capsizing situation developing. Consequently, the crew were unable to carry out abandon ship procedures such as sounding the alarm, meeting at the muster stations, donning lifesaving equipment, or taking other remedial measures such as releasing the fish. The crew on deck scrambled to jump into the skiff as the vessel capsized and sank. The engineer, who was in the engine room at the time while attending to the pumps, was possibly unaware of the situation and was unable to escape the sinking vessel.

2.2 *Situational awareness and workload*

Approximately 15 minutes before the *Miss Cory* capsized and sank, a progressive downflooding situation was identified. Assisted by the *Miss Cory*'s deckhand and the *Proud Venture's* mate, the master of the *Miss Cory* immediately addressed the unsafe situation on board and attempted to reduce the risk of progressive downflooding by pumping water out of the aft hold using the fish pump.

When the crew attempted to transfer the fish pump into the hold, their workload increased significantly, and the master's workload in particular; the master was responsible for addressing the safety hazard as quickly as possible. A high workload can negatively affect situational awareness and perception when an individual's attentional capabilities are focused on a primary task. Workload demands would have required most of the master's attentional resources, reducing the master's available capacity to monitor the evolving situation, maintain awareness of the crew's activities, and comprehend that the vessel was rapidly listing to the point of capsizing. The task of transferring the fish pump into the hold quickly evolved into a difficult situation, because the pump was slightly larger in diameter than the hold opening.

The attentional focus required to transfer the pump into the hold likely contributed to the master's not perceiving that the situation was quickly deteriorating into an imminent capsizing situation. The master's lack of perception of the developing situation prevented the adoption of alternative strategies, such as releasing the fish from the net, that could have saved the vessel or allowed more time to deal with the situation. Consequently, the crew were unable to abandon ship in an orderly manner; the crew members on deck jumped into the skiff as the vessel capsized and sank with one crew member still below deck.

Attention on the task at hand likely affected the master's ability to maintain awareness of the developing situation and make use of alternate strategies or initiate procedures for the crew to safely abandon ship.

2.3 *Emergency preparedness*

An event such as capsizing and sinking can occur rapidly; therefore, crew members need to be ready to respond quickly and effectively. To this end, they must be familiar with the vessel and its emergency procedures, and regularly conduct drills to help with emergency preparedness.

On the *Miss Cory*, there were shortcomings with regard to emergency preparedness:

- There were no procedures for the safe operation of the vessel, or for dealing with emergencies.
- Although the crew had discussed the muster list and associated emergency duties, they did not practise emergency drills on board the vessel.

The crew of the *Miss Cory* were exposed to a number of hazards that stemmed from these shortcomings. For example, just before abandoning the vessel, the crew had not prepared themselves by mustering, donning lifesaving equipment, or considering other options to prevent the capsize such as releasing the fish. The uncoordinated abandonment of the vessel resulted in 1 crew member remaining in the engine room when the vessel capsized.

In addition, the TSB's safety issues investigation (SII)[51] found that fishermen assess and manage risk based on personal experience and do not always conduct drills. Although there are regulatory requirements for fishermen to conduct drills, regulatory oversight is difficult and infrequent for a variety of reasons, including the fact that the majority of fishing vessels are not required to undergo inspections.

Furthermore, although fishermen are required to take Marine Emergency Duties training, which covers emergency drills, the SII found that this training does not instill the importance of safety drills. While programs such as Safest Catch also provide training on how to conduct emergency drills, their success relies on masters and authorized representatives (ARs) taking ownership of safety and conducting drills on a regular basis, which occurs in some cases but not in others.

If formalized emergency procedures are not practised in drills by crew members, there is a risk that their emergency response will be delayed or uncoordinated, potentially endangering the safety of the crew and the vessel.

2.4 *Safe practices and procedures*

The *Canada Shipping Act, 2001*, and the practices of good seamanship, require the development and use of procedures for the safe operation of a vessel and for emergency management. Such procedures should include securing compartments and watertight openings, safe operating guidelines, and conducting emergency drills to assist crews in

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51 TSB Safety Issues Investigation Report M09Z0001, *Safety Issues Investigation into Fishing Safety in Canada*, at http://www.tsb.gc.ca/eng/rapports-reports/marine/etudes-studies/m09z0001/m09z0001.asp (last accessed 05 June 2018).

identifying and managing risks safely. The *Miss Cory* did not have any operating procedures, nor were the master and crew aware of guidance that was available to industry such as the *Herring Food & Bait Best Practices*, which contains relevant information that could have been implemented.

In this occurrence, a number of unsafe practices were identified that carried risks that were not fully recognized by the master and crew:

- The vessel departed and engaged in fishing activities without securing watertight openings that safeguard against progressive downflooding.
- Adequate packing capacity was not readily available.
- Emergency procedures for releasing the fish were not reviewed with the crew.
- The stern section of the net was not tied off at deck level to keep the suspended weight as low as possible.

In the absence of established safety practices and procedures, there is a risk that unsafe conditions will remain unidentified and unaddressed, putting the vessel and crew at risk of accident and injury.

2.5 *Stability of fishing vessels that use a boom*

The use of a boom is integral to certain types of fishing operations, such as purse seining for herring or salmon. Accurate, up-to-date, and comprehensive information on how the use of the boom may affect the stability of these fishing vessels is therefore essential to the safety of these operations. Both the regulator and the AR have roles to play when it comes to the provision of this important information for the crew.

In this occurrence, the *Miss Cory* underwent a stability assessment and Transport Canada (TC) noted that a lifting appliance (boom) was on board. TC notified the AR and the AR's naval architect that if the boom were to be used, additional calculations would be required. However, these additional calculations were never carried out and, as a result, the master was unaware that the vessel would rapidly capsize with a boom load of 5 to 7 long tons. The investigation determined that this was not a unique case; none of the other seiners that operated during the 2017 season were assessed for stability with respect to their booms. This situation highlights a gap in responsibilities and oversight shared between the ARs of fishing vessels and TC with respect to stability information for operations that use a boom. While the onus is on the AR to ensure safe operation of the vessel and therefore the provision of stability information that incorporates the use of the boom, in situations where this is not done, there is little oversight from TC to identify this gap. For instance, once a stability booklet is approved, there are no requirements for periodic verification, nor is the accuracy or comprehensiveness of its data checked during inspections.

Furthermore, the scope of TC requirements for stability booklets does not routinely include an assessment of a boom, despite the fact that it is integral to some fishing operations. When the *Miss Cory*'s stability booklet was approved, TC sent a letter specifying restrictions on the use of the boom.

If fishing vessels that use a lifting appliance during operations do not undergo a stability assessment that includes the lifting appliance, there is a risk that vessels will not be operated safely.

2.6 *Adequacy of fishing vessel stability information*

Once a vessel is in operation and its basic stability parameters are determined, the adequacy of the stability information that is available to the crew is key to ensuring that the vessel is operated safely throughout its lifetime. Crews on fishing vessels need adequate stability information to enable them to determine safe load conditions for gear, cargo, fuel, and other consumables, depending on the operation at hand and type of catch being stowed. Fishing vessels deploy gear, lift loads, and stow their catch while at sea, which means that load conditions frequently change, and it is therefore important that stability information reflect current operations.

The stability booklet on the *Miss Cory* was calculated based on the vessel being fitted and equipped for salmon purse seining, which did not reflect the fittings and equipment required for the herring purse seining operations being conducted at the time of the occurrence. Transport Canada TP 7301 states that it is the responsibility of the AR to ensure that the stability conditions presented in the stability booklet accurately reflect the vessel's loading conditions and modes of operations. That being said, it is common for fishing vessels to undergo changes to their outfitting to allow participation in different fisheries without obtaining updated stability information. In the course of this investigation, it was found that the stability booklets for 10 of the 38 vessels participating in the 2017 Strait of Georgia roe herring fishery did not reflect the vessels' herring operations.

Once a fishing vessel stability booklet is approved, the responsibility for ensuring that it remains up to date and relevant to current operations rests with the AR. TC specifies that modifications to the vessel for use in a fishery different than the one reviewed in this book must not be undertaken until the effects on stability characteristics have been fully assessed. When ARs do not follow through on their obligations to ensure adequate stability information, there are no further defenses, such as a periodic verification by TC, to identify and resolve this shortcoming.

If fishermen are not provided with stability information that is relevant to their current fishing operations, there is a risk that operating practices will compromise vessel stability.

2.7 *Safety issues in the fishing industry*

The SII categorized actions impacting safety into 10 significant safety issues and found that there are complex relationships and interdependencies among them. These safety-significant issues are further analyzed in the SII. The following practices and procedures relating to at least 5 of the 10 safety-significant issues identified in the SII were evident in this occurrence.

Stability

Safety issues investigation findings	Relationship to this occurrence
There are no established guidelines to ensure that information in stability booklets is presented in a simple, clear, or practical format despite TSB Recommendation M94-33.	The *Miss Cory*'s stability booklet, as well as 37 other stability booklets that were examined during the course of the investigation, did not present information in a simple, clear, practical format. The booklet did not reflect the operations of lifting with the boom during fishing operations.
Many fishermen lack an understanding of the principles of stability.	The *Miss Cory*'s crew did not realize the effects of the vessel's raised centre of gravity on its stability, or of the importance of watertight compartments to stop progressive flooding.
There is a lack of awareness of the stability education tools available.	Only one crew member had taken Fish Safe's stability education program.

Training

Safety issues investigation finding	Relationship to this occurrence
The benefits of regular emergency drills in reducing reaction time and increasing team coordination are not well recognized.	Safety drills were not conducted with crew members on board the *Miss Cory*, even though all crew members had taken marine emergency duties training.

Safe work practices

Safety issues investigation finding	Relationship to this occurrence
There is no code of best practice for small fishing vessels, despite TSB Recommendation M03-07.	Although the industry has developed a code of best practices for the food and bait herring fishery, a code of best practices for the roe herring fishery had not been developed at the time of the occurrence.

Safety information

Safety issues investigation finding	Relationship to this occurrence
Safety information may not reach most fishermen or, if received, may be ignored.	None of the crew members on board the *Miss Cory* were familiar with the industry-developed best practices for the food and bait herring fishery.
The distribution of safety information is ineffective.	None of the crew members on board the *Miss Cory* were familiar with the industry-developed best practices for the food and bait herring fishery.

2.8 *Interdependency of safety issues*

The safety of fishermen is compromised by numerous issues which are interconnected. The following safety issues share a complex relationship and were present in this occurrence:

- stability awareness
- unsafe work practices
- training

Past attempts to address these safety issues on an issue-by-issue basis have not led to the intended result: a safer environment for fishermen. The SII emphasizes that, in order to obtain real and lasting improvement in fishing safety, change must address not just one of the safety issues involved in an accident, but all of them, recognizing that there is a complex relationship and interdependency among those issues. Removing a single unsafe condition may prevent an accident, but it will only slightly reduce the risk of others.

The safety of fishermen will be compromised until the complex relationship and interdependency among safety issues is recognized and addressed by the fishing community.

3.0 *Findings*

3.1 *Findings as to causes and contributing factors*

1. A delay in the availability of a packing vessel meant that some of the fish in the *Miss Cory*'s seine died and settled to the bottom, increasing the load on the boom and the side of the vessel.

2. The increased load caused the vessel to list, submerging the rubbing strake.

3. Seawater likely leaked into the vessel's hull from behind the rubbing strake and made its way through the skin of the hull and into the shaft tunnel.

4. Because the inspection plate to the shaft tunnel was not secure, water filled up the aft hold, which negatively affected the vessel's stability.

5. The combined effects of the weight in the net and the progressive downflooding of the compartments in the vessel (particularly the aft hold) caused the vessel to heel over and capsize.

6. Because the *Miss Cory* had not undergone a stability assessment for operations using its boom, there was no means for the master to recognize that the vessel would rapidly capsize with a boom load of 5 to 7 long tons.

7. Attention on the task at hand likely affected the master's ability to maintain awareness of the developing situation and make use of alternate strategies or initiate procedures for the crew to safely abandon ship.

3.2 *Findings as to risk*

1. If formalized emergency procedures are not practised in drills by crew members, there is a risk that their emergency response will be delayed or uncoordinated, potentially endangering the safety of the crew and of the vessel.

2. In the absence of established safety practices and procedures, there is a risk that unsafe conditions will remain unidentified and unaddressed, putting the vessel and crew at risk of accident and injury.

3. If fishing vessels that use a lifting appliance during operations do not undergo a stability assessment that includes the lifting appliance, there is a risk that vessels will not be operated safely.

4. If fishermen are not provided with stability information that is relevant to their current fishing operations, there is a risk that operating practices will compromise vessel stability.

5. The safety of fishermen will be compromised until the complex relationship and interdependency among safety issues is recognized and addressed by the fishing community.

3.3 *Other findings*

1. Of the 38 stability booklets examined in this occurrence, 76% were 20 years old or older, and the vessels' lightship weights have not been verified.

2. Ensuring that emergency position indicating radio beacons are registered and that the registration information is updated regularly can make it easier for search and rescue personnel to find vessels the event of a distress situation.

4.0 Safety action

4.1 Safety action taken

4.1.1 Fish Safe

Following this occurrence, and in light of the existing best practices for the Food and Bait Herring Fishery, Fish Safe conducted outreach with the Herring Industry Advisory Board and the Fish Safe Advisory committee. A committee of 9 experienced fishermen undertook to work with Fish Safe and created a code of best practices in time for distribution before the 2018 roe herring fishery. This code is intended to address unsafe work practices that continue to put fishermen and vessels at risk.

4.1.2 WorkSafeBC

WorkSafeBC is implementing a marine strategy for 2018–2020 that focuses on the fishing industry. Future inspections will include

- ensuring stability documentation is in place (formal stability book, if required) and that instructions and procedures have been implemented, and assessing worker knowledge of content and applicability to the work activities and fishery taking place; and
- with respect to emergency drills and procedures, evaluating how the required procedures have been implemented and whether drills have been conducted.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 25 April 2018. It was officially released on 18 June 2018.

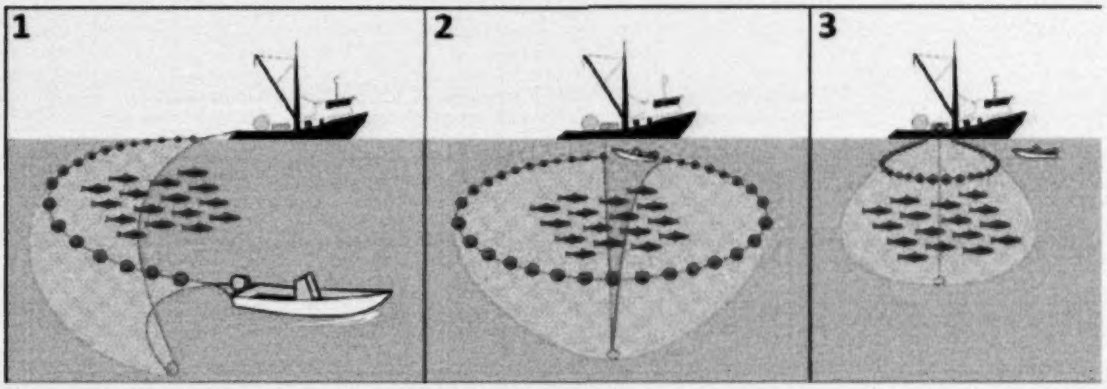
Visit the Transportation Safety Board of Canada's website (www.tsb.gc.ca) for information about the TSB and its products and services. You will also find the Watchlist, which identifies the key safety issues that need to be addressed to make Canada's transportation system even safer. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

Appendices

Appendix A – Purse seining

Purse seining is a method used to catch schooling fish near the ocean's surface by encircling them with a seine (net). Once the fish are encircled, a rope (purse line) running through a series of metal rings, which are attached to the bottom of the net, is winched tight to "close the purse" (Figure A1).

Figure A1. How purse seining works



1 A power skiff sets the net and encircles the school of fish.

2 The bottom of the net is closed from the fishing vessel, creating the "purse" and trapping the fish.

3 The portion of the net still in the water is drummed up to the fishing vessel. The fish are concentrated in a pocket and dried up so that they can be pumped into the vessel's fish holds.

When setting the net, a power skiff is secured to the free end of the net and draws the net off the seine drum and away from the fishing vessel (the seiner). The upper edge of the net is buoyed with floats and remains on the surface. Approximately 60 m below the surface, the lower edge of the net is weighted so that it is suspended vertically in the water.

After the skiff draws the net away from the seiner, the fish are encircled and the skiff brings the free end of the net back to the seiner's starboard side where the net is secured. The skiff then repositions at the seiner's port side where it acts as a side thruster to prevent the seiner from overriding the net.

The seine winch on the deck then draws in the purse line. As the purse line is pulled in, the metal rings are collected on a "ring stripper bar" that is attached to the side of the seiner.

Once the bottom of the seine is closed, which creates a "purse" that prevents the catch from escaping, the net is "dried up".[52] This is done by drumming the seine back on board and releasing the lower edge of the seine as appropriate from the ring stripper bar. This process slowly pulls the portion of the seine that is still in the water toward the seiner, forming a

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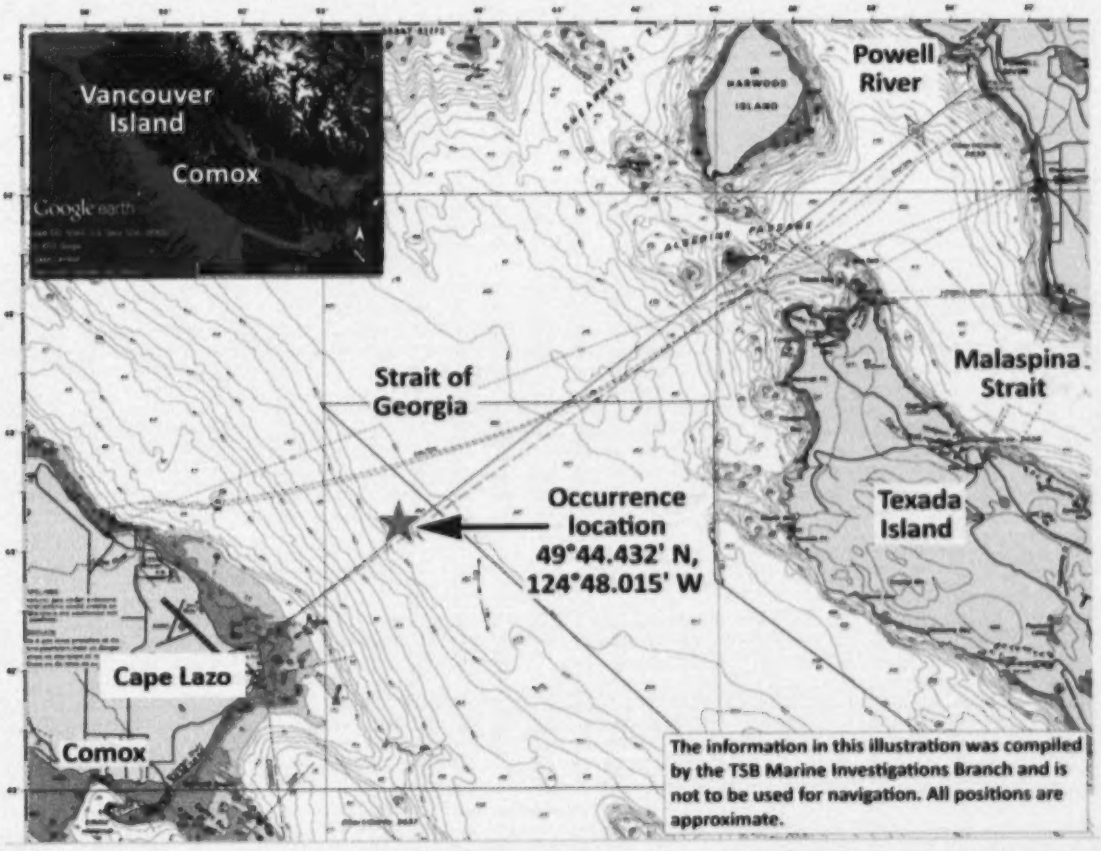
52 When the net is dried up, it is brought on board gradually to minimize the portion of the net containing the fish that is in the water.

concentrated pocket of fish. This concentrated pocket is further reduced by using the boom to lift a stern fleet of net up out of the water to the top of the boom. The fish are then transferred from the seine into the vessel's fish holds using a fish pump.

Drying up is a crucial stage in the purse seining operation. This is because, as the pocket of fish is concentrated by lifting the fleets of net with the boom, additional weight is transferred to the top of the boom, which raises the vessel's centre of gravity.

Appendix B – Area of the occurrence



Appendix C – Roe herring fishery

Herring are migratory fish that typically move in large schools. When trapped or enclosed inside a pursed seine, the school of herring is prevented from swimming and is known to panic or die. The fish then sink and settle to the bottom of the seine, increasing the weight at the bottom of the seine and by extension the weight on the side of the vessel, causing the vessel to list. This reduces the vessel's freeboard and can submerge the edge of the deck into the water.

The roe herring fishery on the British Columbia coast is fished in accordance with a quota system (catch limits) established by the Department of Fisheries and Oceans (DFO). Each licence holder is guaranteed a certain share of the catch. Fishermen also form share pools that allow multiple licences to be fished at the same time and the catch to be shared. This system takes away the race to catch as much fish as possible and makes it easier for DFO to monitor the catch, thus helping the fishery to stay within the preset quotas.

The maximum roe herring catch for the 2017 Strait of Georgia commercial fishery was 28 184 tons, of which 13 013 tons was allocated to seiners. The *Miss Cory* had a quota of 130 tons of roe herring and operated in a pool with 2 other vessels.